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POTASH MINE DUST EXPERIMENTS 1984

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POTASH MINE DUST EXPERIMENTS 1984

by

G. Knight*

ABSTRACT

During the year experiments were carried out to outline airborne dust production and transport at four sites: conveyor gallery; conveyor transfer point; cutting machine and a vehicular travel-way. Both respirable and total dust were measured at each site.

It was found that the cutting machines and conveyor transfer points dispersed large quantities of coarse dust which settled near the generation point. The respirable dust production was also high and only settled slowly in the airways. Dust levels in a conveyor gallery were significant but not high. The dust generation in a wetted well-maintained roadway was low.

It is recommended that men's exposure to inhalable dust (total dust) be determined by personal sampling because of the high variability in space and time.

It is suggested that a study of cutting parameters could lead to a substantial reduction in the quantity of fines produced with resultant advantages in dust levels, spillage and bunker flow.

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ÉTUDES SUR LA POUSSIÈRE DANS LES MINES DE POTASH EN 1984

par

G. Knight*

RÉSUMÉ

Au cours de l'année, on a fait des essais dans le but de déterminer la production et la dispersion de la poussière en suspension dans l'air à quatre endroits: soit dans la galerie de convoyeur, au point de transfert du convoyeur, autour de la haveuse et dans le passage de circulation des véhicules. On a mesuré la poussière respirable et la poussière totale à chaque endroit.

On a trouvé que les haveuses et les points de transfert de convoyeur dispersaient de grande quantité de poussière à gros grains qui se déposait près de l'endroit où elle a été produite. La production de poussière respirable était aussi élevée et que cette dernière ne se déposait que lentement dans les voies d'aération. Alors que dans la galerie de convoyeur les niveaux de poussière étaient remarquables mais non élevés. Et enfin, que la production de poussière dans une voie bien entretenue et humectée était très basse.

On recommande toutefois que la mesure de l'exposition des travailleurs à la poussière inhalable (poussière totale) soit déterminée au moyen d'un échantillonnage individuel, en raison de la grande variabilité de l'espace et du temps.

On propose de plus, qu'une étude des paramètres d'abattage pourrait mener à une importante réduction de la quantité de poussières fines produites avec pour résultat des avantages au niveau des niveaux de poussière, de sa dispersion et celle de la suie.

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INTRODUCTION

Cooperative studies with P.C.S. mining on airborne dust measurement and control in potash mines were started in 1984. It was clear at the start of the studies that there were high concentrations of coarse dust present at the borers and in much of the ore transport system. The dust, while relatively innocuous, is often above the recommended threshold limit concentration of 10 mg/m^3 for total dust. The threshold limit concentration for total dust is based not only on health hazard, but includes comfort and visibility (safety) considerations.

The airborne dust in potash mines has both a higher concentration and a coarser size distribution than present in most mines. The major reason for this is the inability to use water for dust suppression.

The objectives of this stage of the project were to outline airborne dust production and transport in the mine.

The operations examined were:

1) A conveyor-way with no vehicular traffic;
2) A conveyor transfer point;
3) Settlement of dust along a roadway;
4) Dust production at borers (the most used machine for mining potash);
5) A vehicular travel-way with no other dust sources.

DUST SAMPLING

It is clear that the major problem in this mine is the high concentrations of coarse dust that occur near machines. The representative collection of coarse dust is difficult in such places because of the high inertia of the larger particles and the need for accurate isokinetic sampling. However, the air movements are very variable and isokinetic sampling is

impossible to maintain with simple equipment.

There have been a number of approaches to practical 'total' dust sampling. The main ones in use in North America and Europe are open face or closed face filters. There have also been more complex approaches to simulating nasal entry of dust. Some of these have been compared in potash mining by a contractor (1,2).

To study the transport and production of dust in the mines it is desirable to consider coarse and fine dusts separately, because of their different aerodynamic behaviour. The size split used is respirable size selection because the equipment is readily available (3). The experimental plan required three or four sampling sites in each test and duplicate samplers are desirable at each site. This led to a requirement for eight total, and eight respirable, dust samplers, that is 16 pumps, which would be difficult to handle. The Elliot Lake Laboratory had already designed an impactor size selector. This unit was modified so that the component on which the coarse dust was collected could be weighed. The modified unit has an entry equivalent to the closed-face total-dust filter. The entry velocity, at 3 m^3/sec , was in the range of the specifications used in Europe. Thus, the requirement for dust samplers was reduced to eight, with assessments of coarse and fine (respirable) dust on each.

There was some deposition of dust inside the sampler on surfaces, which was not weighed. Brushing this dust off and weighing it suggested that the losses were about 10% of the coarse dust. The losses were ignored in this study, thus the estimates of 'total' dust given in this report are about 10% low.

All the weighing of total dust and some of the respirable dust was carried out on the balance in the mine laboratory. The balance used was found to have a reproducibility of 0.1 to 0.6 mg. It appeared to be affected by

some outside influence causing an erratic zero change. The laboratory was attached to the mill building. The same balance in the Elliot Lake Laboratory had a reproducibility of 0.03 mg. This reproducibility was adequate for the assessment of total dust, but not for that of the respirable dust.

The X-ray diffraction intensity of the five strongest potassium and sodium chloride diffraction lines was measured on all the respirable dust filters. An approximate calibration was obtained against the weights of dust on the filters which were pre and post weighed at Elliot Lake. This XRD assessment then estimates the weight of salt dust on each filter, plus an average proportion of non-salt dust.

All dust samples were collected over a period of 4 hours.

EXPERIMENTS

CONVEYOR-WAY

The objective was to measure dust conditions along a conveyor belt in an isolated gallery. The conveyor-way chosen was on the main ore feed system near the shaft. The experimental section was about 300 metres long with no connecting airways. There was no traffic other than the experimenters during the test periods. The airflow was low and counter-current to the ore transport.

The main dust sources feeding the air entering the test section were vehicular access to an assembly workshop and possibly the conveyor discharge point situated 120 metres from the inlet test section. A sketch plan of the experimental section is shown in Fig. 1. This figure shows the position of the conveyor in the gallery and the sampling positions marked with an X, and a number for each pair. The sampling sites were 5 to 7 feet above the floor for sites 1,2 and 3, and above the original floor for site 4. Site 4 had later floor excavation. The results obtained are shown in Fig. 2.

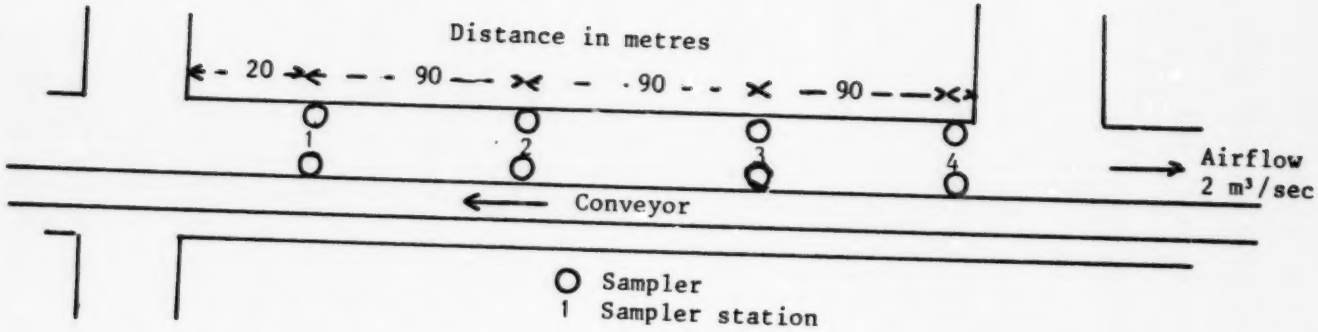

Fig. 1 - Conveyor roadway plan.

The individual dust concentrations measured at each station are at the ends of the vertical line and the means are connected by a line to show the trends along the gallery. The results of three tests for both total and respirable dust are given. The higher of the pair of values is, in most cases, from the station by the conveyor, and the lower from near the remote wall.

It can be seen that the total dust level is high near the intake, and decays fairly rapidly to a nearly constant medium level, 2-5 mg/m^3 in the roadway as expected.

The respirable dust is fairly constant at 0.5 to 1.5 mg/m^3 and forms about one third of the total dust along most of the gallery.

CONVEYOR TRANSFER POINT

The objective was to measure dust production at a transfer point where the airflow could be controlled.

The site chosen was at the junction of two ore-flow sytems where the feed from four or five borers joined that from one. The layout is shown in Fig. 3. The eight sampling stations are shown in pairs as 1 to 4. The four stations at 5 and 6 refer to a later experiment. The incoming air enters with the ore flow on the side conveyor and splits with most air travelling off along the right arm.

The results obtained are shown in Fig. 4. The dust concentrations in the intake, station 1, are similar to those in most of the conveyor gallery as given in Fig. 2. It can be seen that there is a substantial rise in dust levels as the air passes the transfer point. The highest concentration measured was 100 mg/m^3 at the station about 5 m from the transfer point.

DUST DECAY ALONG A GALLERY

The objective was to estimate the rate of settlement of dust as the air passes along the long galleries towards the points of use. The site chosen

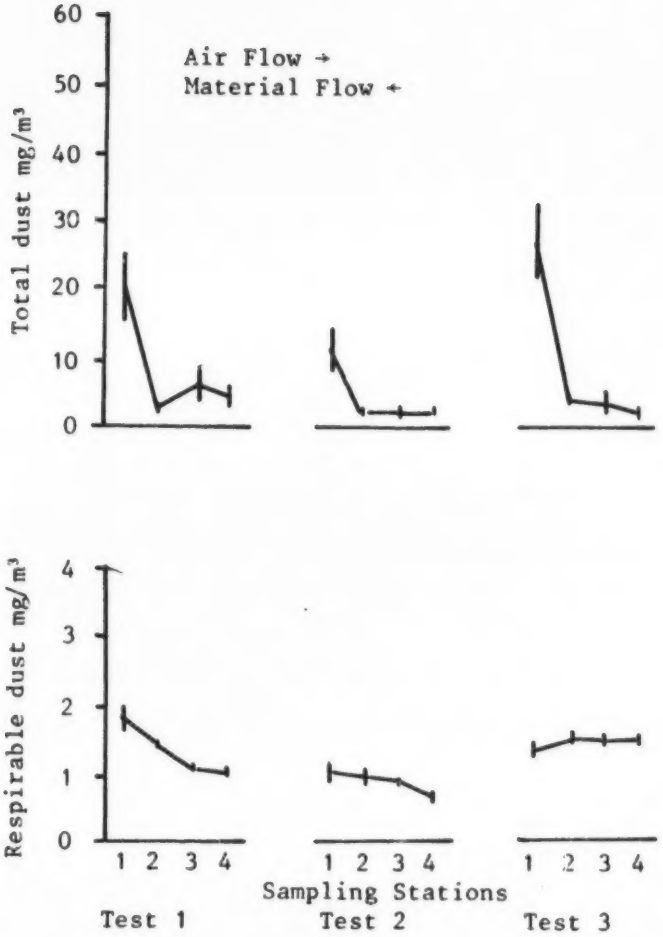

Fig. 2 - Conveyor-way dust measurements.

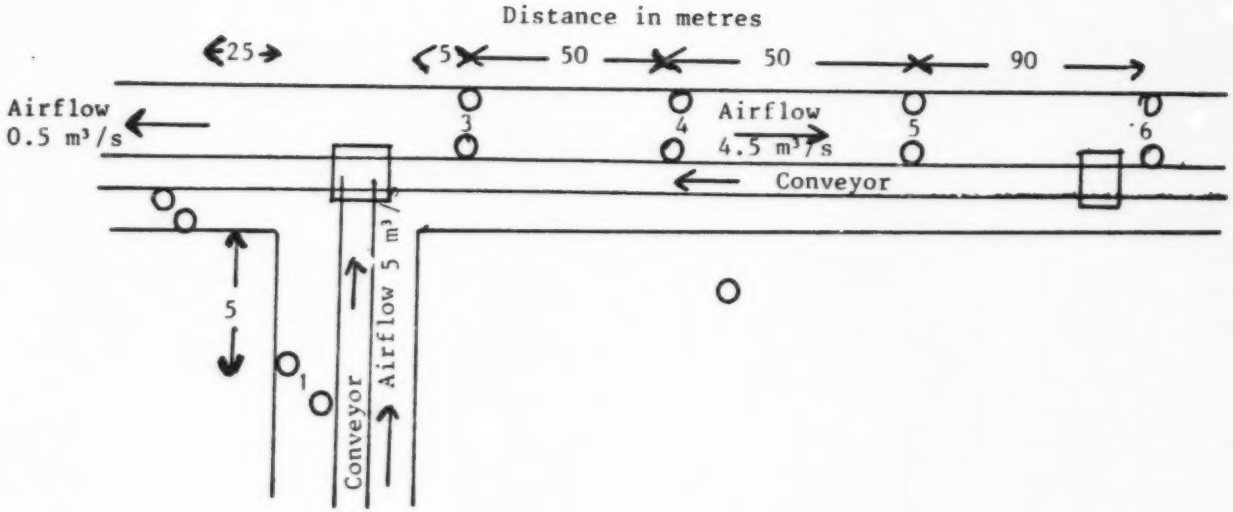

Fig. 3 - Conveyor transfer point plan. Also shows experiment 3 plan.

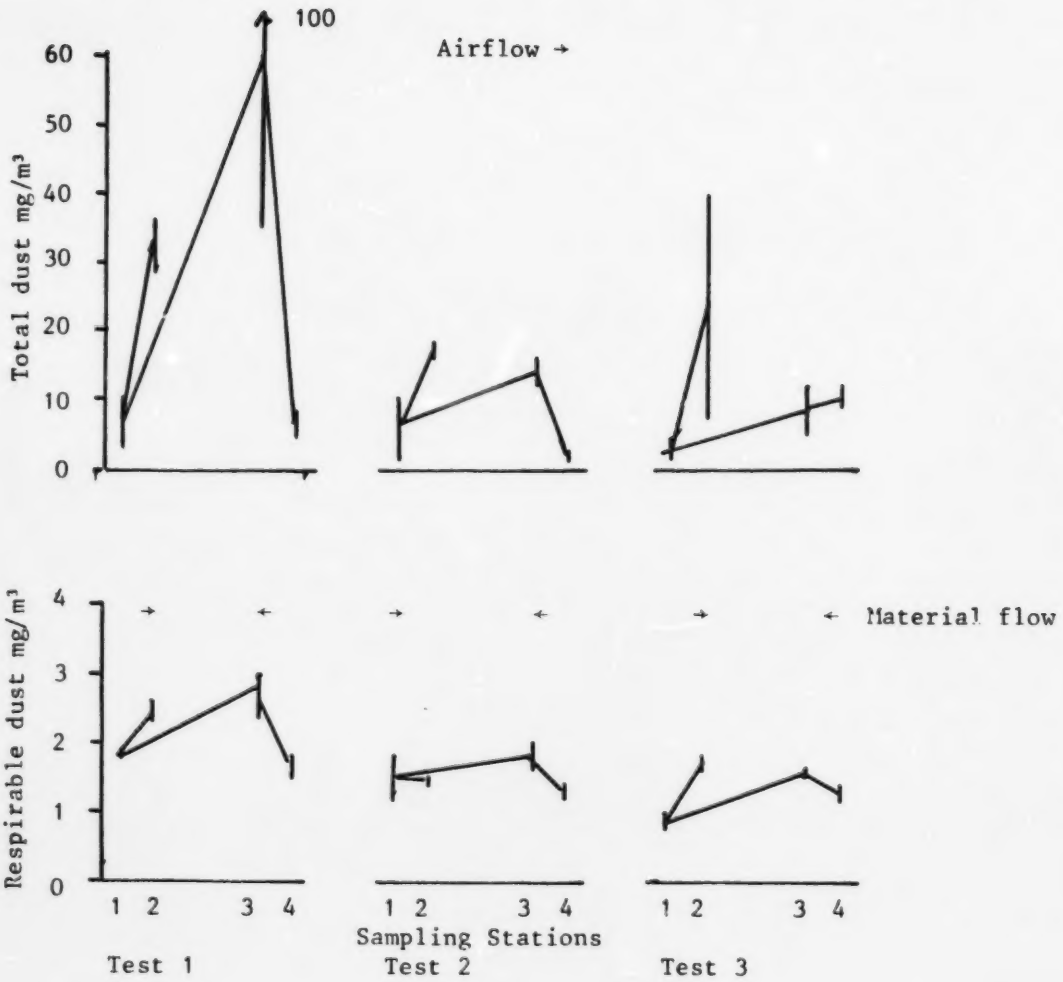

Fig. 4 - Transfer point dust measurements.

was the same transfer point as in the previous experiment and the tests were carried out during periods when the borer feeding the in-line belt was not in operation. The in-line conveyor feeding the transfer point between stations 5 and 6 was turned off during each test.

The site is shown in Fig. 3. The sampling stations used were the pairs at 3,4,5 and 6. The results obtained are given in Fig. 5. It is apparent that in the second test very little ore could have been carried and the results might be considered as indicating the dust concentrations to be expected when empty belts are run. Some dust dispersion is to be expected in the empty belt condition. The other two runs show a substantial reduction in both total and respirable dust in the first 50 or 100 metres of the gallery.

No explanation has been found for the much higher dust levels at station 6 during the third test than during the first. No activity was noticed in this area during test 3. It is possible that there had been a spillage leading to dust dispersion by the empty belt.

CUTTING MACHINE

The objective was a preliminary determination of the dust production in cutting potash.

The cutting machines, borers, were on the second and third pass, respectively with through ventilation. The layouts are shown in Fig. 6. The results are given in Fig. 7. It can be seen that the dust concentrations at the eight sampling stations do not meet the expectations of low intake levels and a major rise as the air passes the borer between the pairs of stations 2 and 3.

It is clear that many more measurements and observations are required to understand this major dust source.

TRAVEL-WAY

The objective was to examine dust production by vehicles on a well-

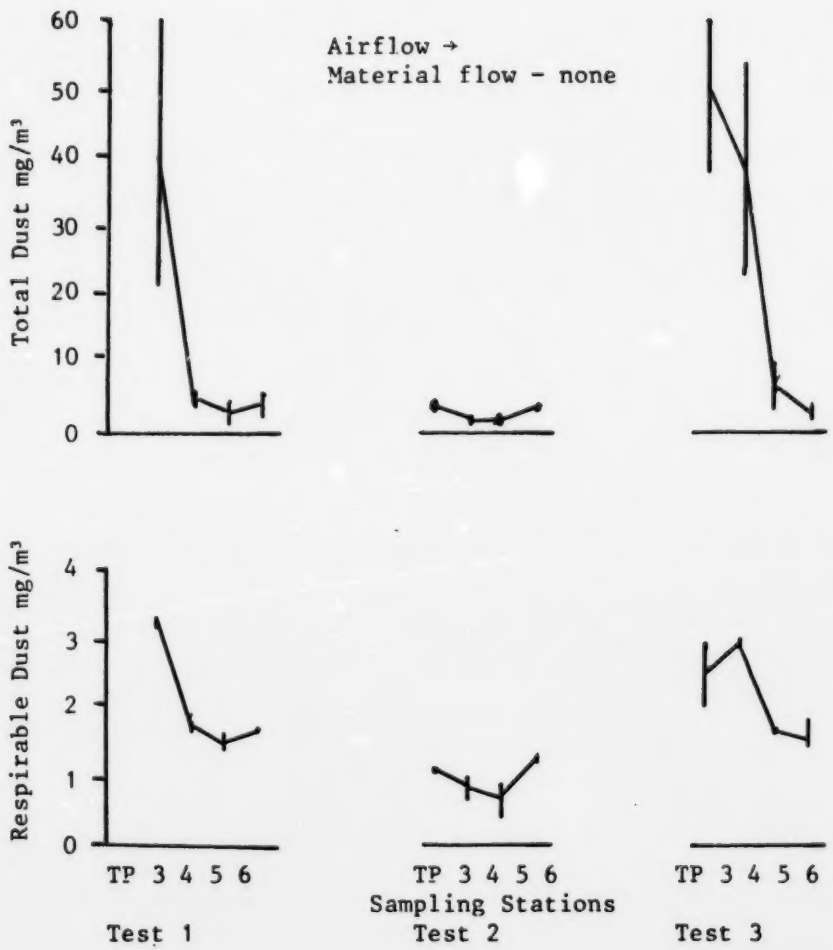

Fig. 5 - Dust measurements along a galleryshowing settlement.

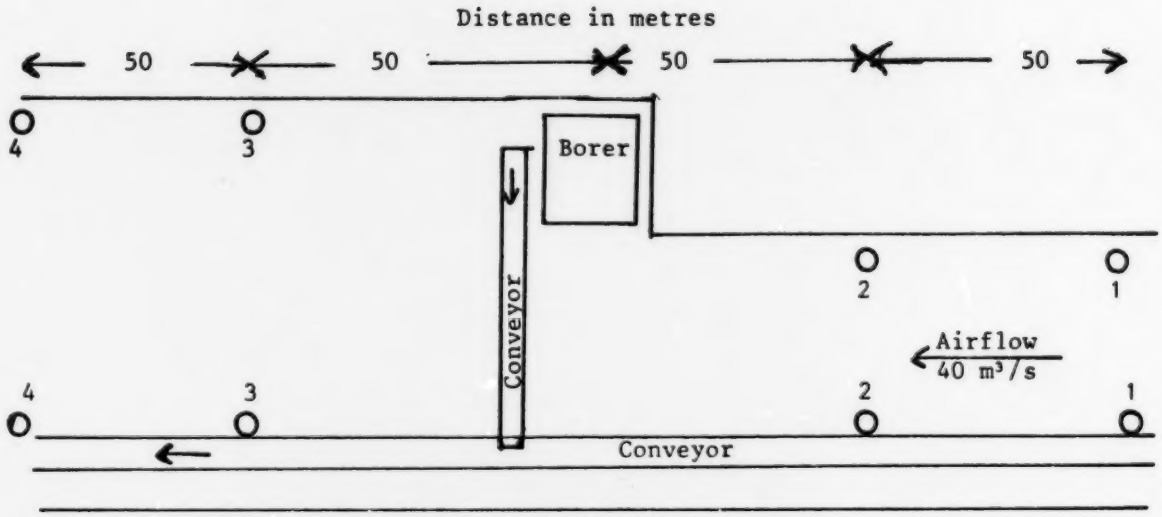

Fig. 6a - Borer on third pass.

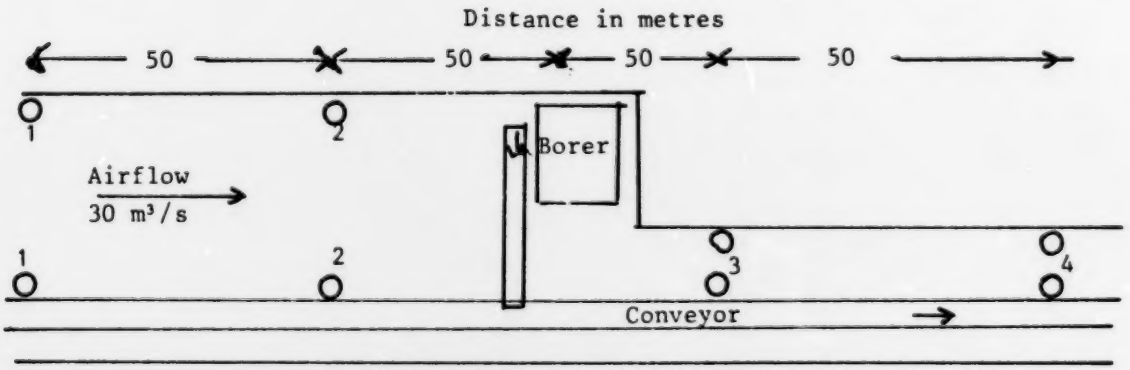

Fig. 6b - Borer on second pass.

Fig. 6 - Cutting machine layouts.

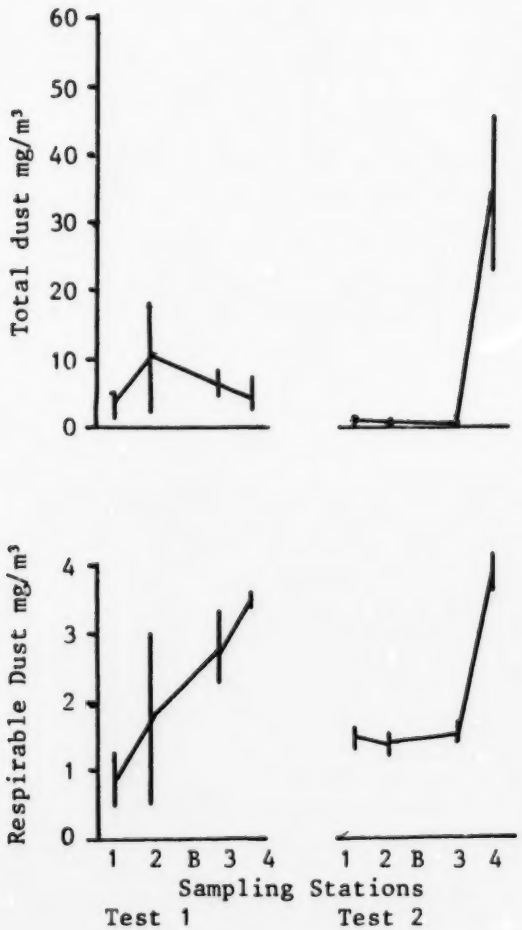

Fig. 7 - Dust measurements at borer.

travelled roadway. The site chosen was a 300 metre length of roadway near the main shaft. This is the route from the shaft to the workshops, stores and major mining areas. The roadway is compacted and watered often. The layout is shown in Fig. 8, and the results in Fig. 9. It can be seen that the dust concentrations are low on two of three tests. On the first test the concentrations are high for the intake air. No dust source was seen which would explain these high values.

The results suggest that there is no problem with well dampened roads. Visual observation shows that a lot of dust is stirred up by vehicles travelling in the tertiary roadways which are not wetted and are thickly coated with dry dust.

AIRBORNE DUST PRODUCTION

In our previous underground measurements of dust production, fairly close estimates of ore tonnage and ventilation during the sampling periods were made (4). The results were given in milligram/tonne (mg/t) of ore or mg/m of hole depth drilled. The dust productions are determined from the increase in dust concentration between intake and return, the airflow and the ore tonnage. Because of the lack of equipment it was not feasible to measure tonnage of material on the conveyors. Also because of the usually low air velocities and high dust loadings, it was not practical to record air velocities during the sampling period. Thus for this preliminary study, only average production rates have been used for tonnage and the nearest mine ventilation survey augmented by time of travel air velocity measurements in some low flow galleries. Table 1 shows the estimated dust production rates at the borer and transfer points.

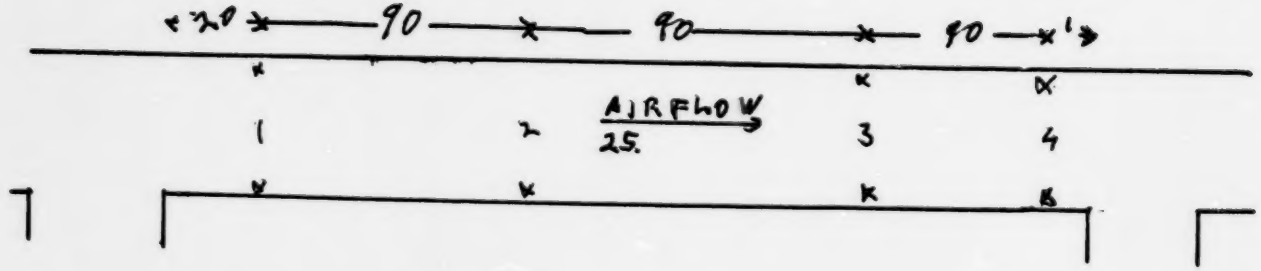

Fig. 8 - Travel-way plan.

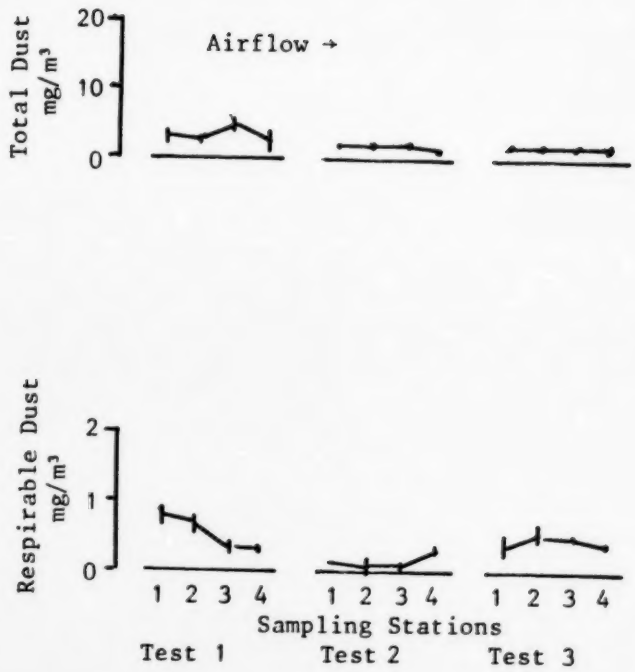

Fig. 9 - Dust measurements in travel-way.

Table 1 - Dust production rates

Site	Total Dust mg/sec	Total Dust mg/tonne[1]	Respirable Dust mg/sec	Respirable Dust mg/tonne
Borer #12	140[2]	5600[2]	108	4300
Borer #3	1000	33000	72	2400
Transfer point	77	10	4.3	0.6
	36	5	1.4	0.2
	52	7	3.4	0.4

[1] Based on average production per month.

[2] This figure appears very low. It is assumed that most coarse dust settled prior to the sampling station.

DISCUSSION

It is clear that large quantities of coarse dust are dispersed into the air at borers and at transfer points. This dust settles rapidly and it is difficult to measure all of it. The concentrations vary between the two sides of the galleries. It is evident that there are large variations in space and time, and that therefore, there is probably a poor correlation between fixed station measurements and personal exposure in the vicinity of major dust sources. In addition, men may only spend a small amount of time in the vicinity.

If the requirement is to measure men's 'total' dust exposure as the 10 mg/m^3 mean 8 hour threshold limit value implies, then personal dust sampling is probably essential to determine compliance or the need for control. However, the standard of 10 mg/m^3 is also related to visibility hazards. Clearly, visibility was severely restricted in some areas, such as the feed gallery above the underground storage bunkers, creating a safety hazard. Visibility is not simply related to dust concentration by weight, but depends on size distribution and other dust properties. Visibility hazards can probably be best determined by optical techniques such as the range at which a contrasting object can be distinguished.

Airborne dust emissions could probably be substantially reduced by improving cutting technology to mine a substantially coarser product with a correspondingly smaller proportion of fines. This would probably also improve flow of ore in storage bunkers and decrease spillage and clean-up costs at transfer points.

Wetting is the usual method for binding dust and preventing its dispersion into the air. However, its use may lead to build-up of caked ore on surfaces such as inside bunkers and give rise to excessive cleaning

requirements. The use of a small carefully controlled amount of water may be feasible after improvements in cutting technology.

As coarse dust is the major problem and fine dust is not serious, dry dust collectors, such as cyclones are practical. The dispersion of coarse dust at such places as transfer points could be greatly reduced by enclosure with air extraction through a cyclone. The quantity of collected dust would be large, and thus should be returned to the belt. The best position for the fine dust feed is onto the outgoing belt before the transfer point so that the dust is covered by the coarser ore.

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